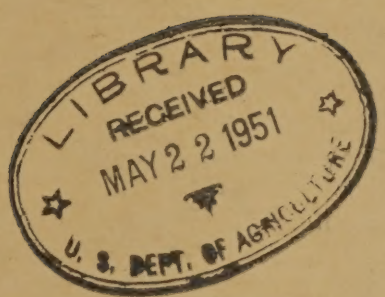
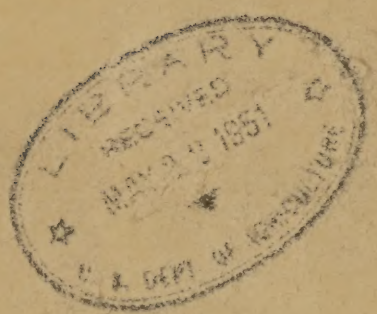
MEMORANDUM OF OBSERVATIONS AND SUGGESTIONS ON AIR-DRYING OF IRISH POTATOES IN REGIONS OF LOW RELATIVE HUMIDITY





By: H. L. Stafford
U. S. Agricultural Adjustment Administration.
Boise, Idaho

800060

Boise, Idaho 5c
October 27, 1941

MEMORANDUM

From: H. L. Stafford, Field Officer
Agricultural Adjustment Administration
Western Division - Boise, Idaho

To: Idaho Experiment Station - Moscow, Idaho

Western Regional Research Laboratory
- Albany, California

Subject: Air Drying of Irish Potatoes

The object of this memorandum is to place before the Experimental and Research Institutions items of information which were obtained incident to administration of the 1940-41 Potato Diversion Program; outline subsequent experiments in the preparation, arrangement and exposure of potatoes for drying by natural means; recommend consideration of a project agreement between the institutions under which the practicability of air drying may be investigated; and to suggest types of equipment for initial use in such investigations.

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R. L. Stafford, Field Officer
Agricultural Adjustment Administration

Irish Potato Diversion Program

By order of the Secretary of Agriculture, the Surplus Marketing Administration on February 15, 1941, offered to pay 25¢ per cwt. for specification A grade potatoes diverted to livestock feed. This offer was made applicable in the late Russet producing areas of Nebraska, Wyoming, Colorado, Utah, Idaho, Washington, Oregon, and the Tulelake area of California.

Observations

The great bulk of potatoes contracted for diversion were fed in the raw stage directly to livestock. In some isolated sections movement of livestock to the open range left sizeable lots of contracted potatoes unfed and on hand in the grower's cellar.

In view of the fact that contracting farmers were in most instances specialty crop growers without livestock, compliance became a problem. Chopping and ensiling was recommended. A request for permission to chop and air-dry the potatoes for later feeding was sent to Washington. The Surplus Marketing Administration granted conditional permission to prepare potatoes for air-drying as a method of acceptable compliance. For want of more suitable equipment and arrangement, potatoes were spread on a mulch of straw or hay and chopped with a shallow set disc harrow. It is estimated that some 100,000 bags of potatoes were treated in this manner. On a smaller scale a wide variety of devices were employed to slice potatoes.

The method of driving back and forth with a disc harrow proved satisfactory where the depth of mulching material was sufficient to prevent the disc coming in contact with the soil and the spread of potatoes was sufficiently shallow to permit air circulation. Routine inspections of a number of these lots were made throughout the summer. It was observed that some particles dried remarkably fast. In turn it was noted that other particles of similar dimensions were drying slowly. Oblong potatoes cut crosswise into equal halves starch side exposed upward were drying only slightly faster than starch side down. Again, potatoes split lengthwise into equal halves irrespective of exposure were drying very slowly when compared to other shapes and forms. Throughout these lots other forms and shapes were found drying rapidly whether or not they were exposed to the sun.

In an attempt to appraise the progress of drying during the period elapsed since preparation, samples were sorted to classify as dry, semi-dry, and wilted. After a little study of these sorted lots it became obvious that the variations of dryness were almost directly proportional to the difference in the ratio of starch exposure to skin-covered exposure. This situation then suggested that to dry

potatoes in a reasonable time it was not only necessary to cut the potatoes but to size the material uniformly. Control of the cross section appeared important. Distribution of the skin in a manner impairing its ability to retard evaporation seemed equally important.

In addition to the miscellaneous lots above-mentioned, reference is had to a project carried out by Mr. Cecil Buell of Tulelake, Siskiyou County, California. Mr. Buell had access to about 20 carloads of diverted potatoes at a neighborhood cellar about one mile distance from his farm. It being late spring Mr. Buell was confronted with the problem of salvaging full feed value before spoilage should occur. A rather carefully devised plan chosen by Mr. Buell involved the following: A few pounds of potatoes were weighed, chopped and artificially dried to determine the dry matter recovery. When the potatoes were dried sufficiently to keep in storage 450 pounds dry matter per ton of raw potatoes was available. Mr. Buell constructed a cutter by substituting a flat disc of 3/16" steel plate in lieu of a circular cordwood saw using the mandrel shaft and bearings. Holes of approximately $1\frac{1}{4}$ inches were distributed over the area of the disc, over which were attached standard root cutter blades. These were circular or spoon-like in shape. The machine had satisfactory capacity and, did thoroughly cut the potatoes. The vegetation was skinned off of a strip of field acreage about 13 x 175 yards discounting the driveway up the center. The cut potatoes were spread very thinly from $\frac{1}{2}$ to $1\frac{1}{2}$ inches in depth. Starting from one end the spread was continued in this manner for the length of the plot; the second layer blanketing the first layer from point of beginning. The process was repeated until the entire 20 cars were cut and spread. This cutting and spreading operation was carried on during the month of June and completed by the Fourth of July. During the third week of June one specially spread load of material was dry enough to permit milling after six-days exposure. Samples of this were forwarded to the Surplus Marketing Administration at Washington. The analysis obtained follows:

Analysis Requested	Average	Moisture Free Basis
Moisture	12.34%	
Ash	3.90%	4.45%
Nitrogen	1.13%	1.29%
Protein Nitrogen (N x 6.25)	7.06%	8.06%
Starch	67.68%	77.21%
Water Solubility (mg. per 100 ml. water)	155.8	
Total volatile matter	96.11%	95.55%
Crude Fiber	0.88%	1.01%

The project at Tulelake demonstrates that potatoes will readily dry under midsummer temperatures of that area when thoroughly chopped by almost any type of device and arranged to permit good air circulation. It appears, however, that economy of space in this instance

was gained at the expense of time. On the other hand, the time element involved here afforded opportunity to get the surface moisture of each particle evaporated immediately to prevent the spread of rot organisms. This is important. Indeed, in all instances where potatoes were arranged in any manner retarding or preventing air circulation serious loss of quantity and damage to quality were the result. The spread of rot organisms through improperly ventilated lots seals over into a jell-like mass, stopping evaporation and results in complete spoilage.

Observations above outlined led the writer to conclude that probably there were at least five prime factors involved in the process of air drying potatoes efficiently. These factors are thought to appear in the following order of importance.

(1) Sizing of the material
(2) Arrangement of exposure
(3) Temperature
(4) Relative humidity
(5) Velocity

Subsequent Miscellaneous Experiments

Numerous small lots of potatoes were cut random lengths with uniform cross sections. On about the tenth of August, new crop culls from Caldwell, Idaho, were put through a potato stripper such as is used to prepare potatoes for uniform frying in deep fat. This grid device provided material of three-eighths inch cross section in random lengths. The potatoes were passed through the grid endwise.

The sizing gave exposure ratios of three starch surfaces to one of skin covering for the vascular zone and ratios as high as 50 starch to two of skin covering from the center sections.

When placed three inches deep on a three-mesh hardware cloth tray suspended horizontally three feet from the ground with full exposure to sun and wind, this material dried thoroughly in 24 hours (August 10, 1941). Prepared random lengths with cross sections of one-half inch were observed to dry under the above condition in 36 hours, three-fourths-inch cross section in 60 hours, one-inch cross section in 80 odd hours. It is believed that owing to difference in degree of maturity, moisture content, and composition, the rate of evaporation or drying for individual potatoes will differ accordingly. One small lot of individually large potatoes were sized one-inch cross section, lengthwise stripping, and placed between two hardware cloth screens spaced six inches, height twelve inches and length eighteen inches, arranged vertically (i.e. horizontal dimension six inches) and suspended with full exposure to sun and wind four feet from the ground. This was observed to be dry in 36 hours. It is believed that acceleration in this instance was due to (1) small lot of material (2) porousness providing good ventilation (3) extreme ratio of starch to skin surface

exposed. Boise weather data for August 10 to 15 follows:

1941 Aug.	Temperature	Relative Humidity	Velocity	% Possible Sunshine
10	80.2	47	7.7	65
11	73.0	70	8.2	5
12	69.2	67	6.7	77
13	71.2	53.7	6.0	100
14	77.2	37.5	7.7	80
15	78.5	37.5	11.5	83
Average	74.9	52.1	7.9	68

About September 1, 1941, small lots of one-half inch and one-inch cross sections were again arranged as described for the August 10th checks. These lots were arranged along a driveway surrounded by large trees and other objects tending to exclude the sun from 11 a.m. and to some extent retard velocity. The one-half inch cross section material was dry at the end of three days, whereas the one-inch cross section material required nine days. The degree of dryness in these experiments was determined by brashness of the material. The dry material being brittle afforded an abrupt clean break whereas partially dry material would bend rather than break.

Boise weather observations for the above were as follows:

1941 Sept.	Temperature	Relative Humidity	Velocity	% Possible Sunshine
1	60.5	47.0	7.2	16
2	60.0	61.5	14.2	24
3	57.0	72.0	8.7	23
4	65.0	59.0	5.7	65
5	69.6	49.5	8.2	79
6	61.5	55.2	14.5	73
7	55.7	56.2	17.7	67
8	54.7	52.5	7.2	88
9	64.1	35.7	9.2	49
Average	60.9	54.3	10.2	54

It will be observed that all material prepared by hand was clean cut and free from granulations, pulp, or fine crushed particles.

The following paragraph describes an attempt to mechanically control the cross section and starch exposure:

By means of power driven plungers about 1500 pounds of potatoes were sized through a grid providing random lengths of one-half inch cross section. The material prepared with this machine contained a high percentage of fine, granulated particles. The pulp material was comparable in size to coarse sawdust. When put out to dry the pulp portion served definitely to exclude air circulation. The lot was spread on a semi-flat shingle roof, north slope, shaded from the sun by trees. The spread was varied in depth ranging two, three, four, five, and six inches, an equal area provided for each depth. The two and three-inch depths dried satisfactorily, whereas, the four-inch material spoiled in spots depending upon amount of fine material present. The lots spread at depths of five and six inches spoiled to a degree requiring handling or turning four or five times. Where the spread of rot organisms was complete the mass spoiled despite handling. Several points of interest developed in this instance.

It appears that finely ground pulp-like material cannot be readily separated from the mass except by washing or screening. The tonnage involved in the pulp portion when separated will require an altogether different treatment for drying. Any pulp material dried along with the more desirably sized forms is apt to be lost.

The presence of both rot organism and large quantities of pulp and failure to immediately evaporate surface moisture presents a critical situation. The presence of granulated material aggravates the situation to the extent that such material is present. Sizing machinery will not be efficient unless the product of such equipment is clean cut and free from granules or pulp.

Further observations were made in connection with the chopping of about 25 tons of cull potatoes at the University of Idaho Substation at Caldwell. The cutting equipment consisted of a custom-built root cutter similar to the device built at Tulelake as described elsewhere and a popular make ensilage cutter. The chopped material of either of these machines was estimated to contain from 30 to 50% granules and pulp.

Poult trays of hardware cloth on frames 4' x 8' were available approximating 2880 square feet. All but two of these frames were arranged end to end, horizontal suspension space six inches from the ground on 2" x 6" x 16' rough lumber set up edgewise. Air circulation beneath these trays was somewhat retarded by the surrounding growth of Russian Thistles, the location being on waste land. The hardware cloth consisted of three sizes; one, two, and three mesh

per inch. There were relatively few frames of the three-mesh size. All frames were placed screen side down. Construction of frames provided a four-inch rail side and end. Ten or twelve frames were loaded to a depth of four inches to eight inches from side to crest. The more desirable cross sections of the mass varied from one inch to one and one-half inches irregular in shape, - average low ratio starch to skin surface exposure. The volume of pulp excluded air circulation entirely. Rot organisms were active. These frames had to be partially unloaded; the remaining contents had to be turned three or four times. When handling and drying had proceeded to the point that most of the pulp material had dropped through the screens, the rate of drying was then satisfactory, rot contamination taken into consideration.

In connection with the three-mesh cloth, it was noted that a film of juices collected across the narrow meshes not unlike soap bubbles. This syrup-like film excluded vertical air movement entirely.

The other trays were loaded from two to three inches. However, drying did not proceed satisfactorily until turning or stirring worked the granular material through the screen.

In view of the above experience two of the trays were set up edgewise, cloth face to face, top and bottom spacing was four inches. The sag in the cloth gave a variable width up to six inches center section. Coarse material was obtained by passing machine run material over a one inch mesh screen eliminating practically all of the pulp. Surface evaporation was observed to take place immediately. Considering the percentage of pieces with low starch to skin, the lot dried rapidly and satisfactorily without further attention. Bulk shrinkage in height in this instance was noted to be 60% when dry after a period of about three weeks.

A similar lot of screened material was placed four inches deep on one of the horizontal trays. Surface evaporation was satisfactory, but the rate of drying in this instance was assumed to be much slower, requiring about four to five weeks to attain the condition observed with the vertical arrangement at the end of three weeks.

At the outset of operations at Caldwell, (September 10) a small lot of rather large potatoes were stripped end to end with a one-inch square cross section and piled at random on the ground. This material was assumed to be dry enough for storage or milling by September 18.

From ten to twelve tons of the machine run material was spread on a mulch of straw from one to three inches in depth. Subsequent checks of this material indicated that weather permitting, the lot would be satisfactorily dry at the expiration of six weeks.

Boise Weather Station data September 10-18 follows:

1941 Sept.	Temperature	Relative Humidity	Velocity	% Possible Sunshine
10	68.7	43.0	12.5	62
11	55.7	50.7	13.7	28
12	53.0	66.7	4.5	75
13	54.0	67.5	9.2	78
14	54.7	57.2	7.5	10
15	57.7	57.2	9.5	69
16	62.5	44.2	12.0	100
17	68.0	43.2	8.2	100
18	62.0	44.2	14.0	28
Averages	59.6	52.6	10.1	61

The following table compares September 10-18, 1941 to mean values for April, May, June, July, August and September of 1940.

1940	Temperature	Relative Humidity	Velocity	% Possible Sunshine
April	50.0	60.0	10.6	63
May	61.3	43.6	10.1	83
June	69.6	35.0	10.1	86
July	74.9	36.3	8.8	78
August	74.2	29.3	9.2	86
September	63.2	64.0	8.9	48

The following table of data taken at Boise, Burley, Gooding, Idaho Falls and Pocatello for September 10-18, 1941 offers little perhaps except to indicate that factors contributing to possible air drying are

equally favorable in other sections of the Snake River Valley as one may expect for the Boise vicinity.

1941 Sept.	Temperature					Relative Humidity					Velocity					% Possible Sunshine	
	2739* Boise	4180 Burley	3572 Gooding	4742 Idaho Falls	4477 Pocatello	2739 Boise	4180 Burley	3572 Gooding	4742 Idaho Falls	4477 Pocatello	2739 Boise	4180 Burley	3572 Gooding	4742 Idaho Falls	4477 Pocatello	2739 Boise	4477 Pocatello
10	68.7	68.2	69.3	55.1	74.9	43.0	30.0	31.2	52.0	15.2	12.5	7.7	8.7	6.2	15.0	62	87
11	55.7	51.9	52.3	63.9	57.5	50.7	61.2	40.2	33.5	45.5	13.7	12.1	8.2	16.2	7.2	28	44
12	53.0	51.2	53.1	51.6	55.2	66.7	55.7	31.7	59.0	36.7	4.5	9.5	8.7	9.2	6.0	75	87
13	54.0	52.2	53.9	50.1	56.6	67.5	50.0	30.5	50.5	35.7	9.2	10.0	6.2	11.5	11.0	78	100
14	54.7	54.5	55.2	51.4	57.2	57.2	50.7	31.5	46.2	37.5	7.5	5.7	10.0	16.7	13.2	10	56
15	57.7	48.5	55.6	53.7	49.9	57.2	59.7	35.7	48.7	52.7	9.5	9.7	13.5	17.2	13.5	69	30
16	62.5	66.7	61.3	48.5	60.7	44.2	41.5	28.0	54.5	36.2	12.0	8.0	11.2	6.7	6.2	100	100
17	68.0	68.7	70.2	57.8	76.4	43.2	51.5	30.2	47.2	18.7	8.2	12.7	10.5	10.0	14.0	100	100
18	62.0	62.2	64.9	64.7	63.1	44.2	44.2	30.0	34.2	43.0	14.0	11.2	11.7	12.0	14.2	28	65
Aver age	59.6	58.2	59.5	55.2	61.3	52.6	49.4	32.1	47.3	35.7	10.1	9.6	9.9	11.6	11.1	61	74.3

* Elevations

Conclusions

Potatoes may be air-dried under Idaho climatic conditions during the spring, summer and fall months of April through September.

Efficiency of operation will depend upon the facilities used.

Sizing equipment and arrangement of exposure appear to be the most important items.

Sizing machinery to produce a uniform cross section of particle providing the highest possible ratio of starch exposure to skin covering is desirable.

Arrangement of racks or bins should be organized to permit thorough ventilation of the mass and to permit constant air change about the exterior.

Ideal sizing would result in a maximum length strip of uniform cross section, providing minimum skin covering to starch exposure.

Oblong forms of uniform square cross section when piled at random assume a porousness which facilitates ventilation.

Thorough laceration of the skin prior to sizing would no doubt hasten the process of dehydration and appears worthy of investigation.

The vertical arrangement of exposure appears to provide maximum benefit of velocity.

The vertical arrangement due to gravity offers continuous operation, and appears readily adaptable to use of mechanical conveyors.

The volume of potatoes grown in regions of low relative humidity when factored by from 20% to 40% for the unmerchantable, if not uneconomical part of the crop, appears to justify wide experimentation in dehydration.

Where 450 pounds of dry matter to the ton of raw potatoes is recovered and of a quality suitable for storage and transportation, the volume of residue available for industrial utilization the year around is appreciable.

In view of the general problems facing the potato industry of Idaho, it is recommended:

That the facilities of the Idaho Experiment Station and the Western Regional Research Laboratory at Albany, California, be enjoined by agreement to establish such necessary means and equipment at the Bingham County, Aberdeen, Idaho Substation, as are necessary to determine the practical limits of dehydrating potatoes by atmospheric means.

That such equipment as may be established at Aberdeen be constructed sufficiently portable to allow removal and erection at the Canyon County Substation near Caldwell, Idaho.

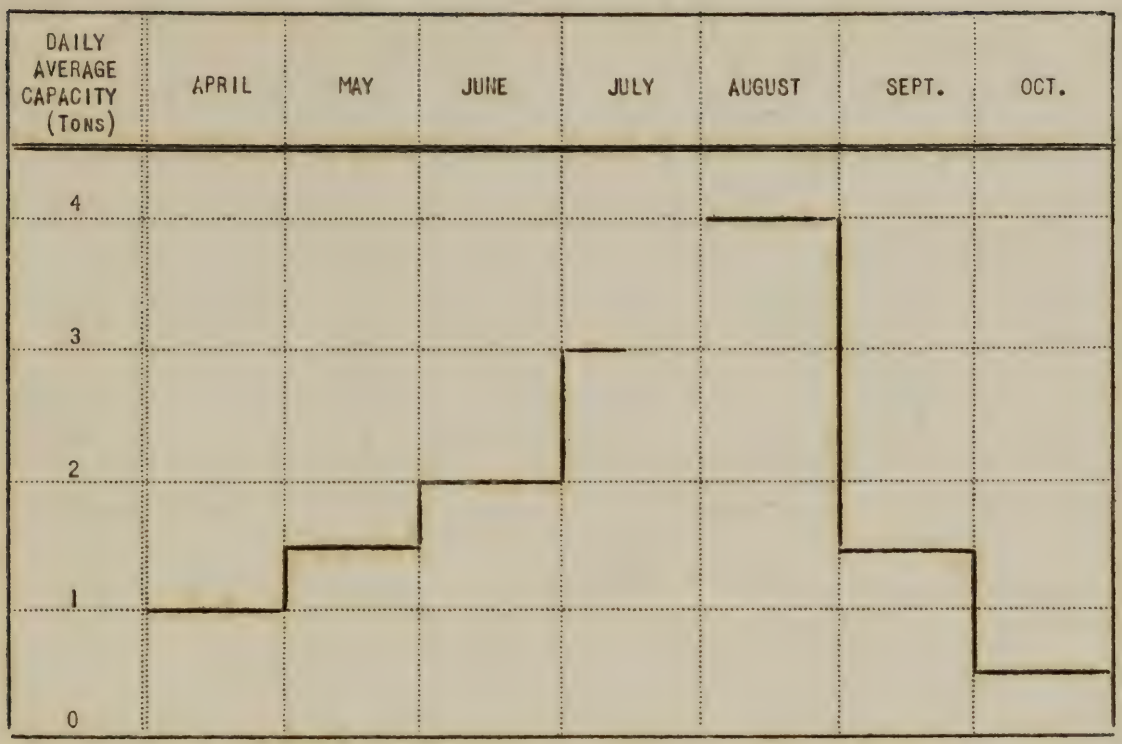
The potatoes available at Aberdeen during the months of April, May and June will be of old crop storage. New crop potatoes are ordinarily available at Caldwell about August 1. The interim between July 15 and August 1 provides opportunity to move such equipment at no loss of operation.

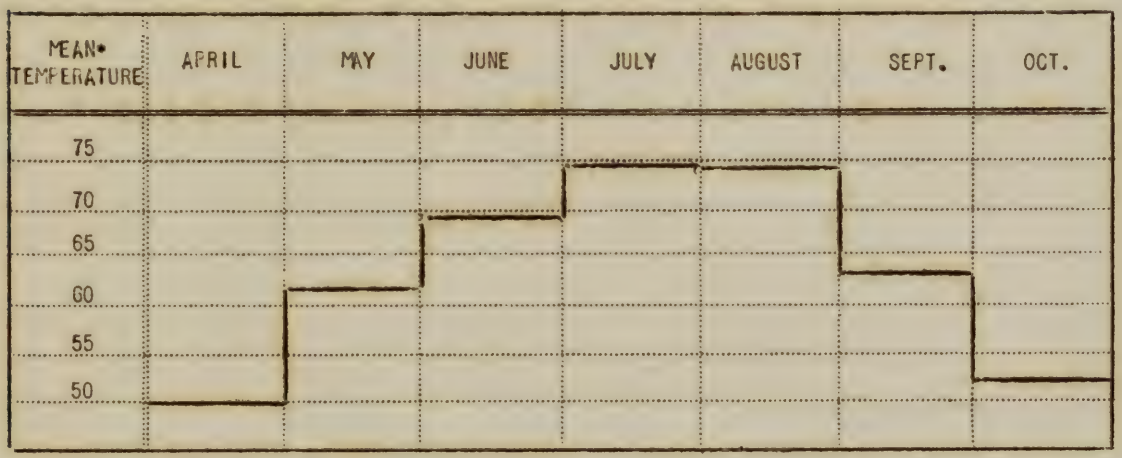
It appears possible to carry on experimental work with both old and new potatoes during the same season. It is recommended that provisions be made to produce residue in a sufficient volume to permit working with this material from the standpoint of storage, transportation and industrial utilization.

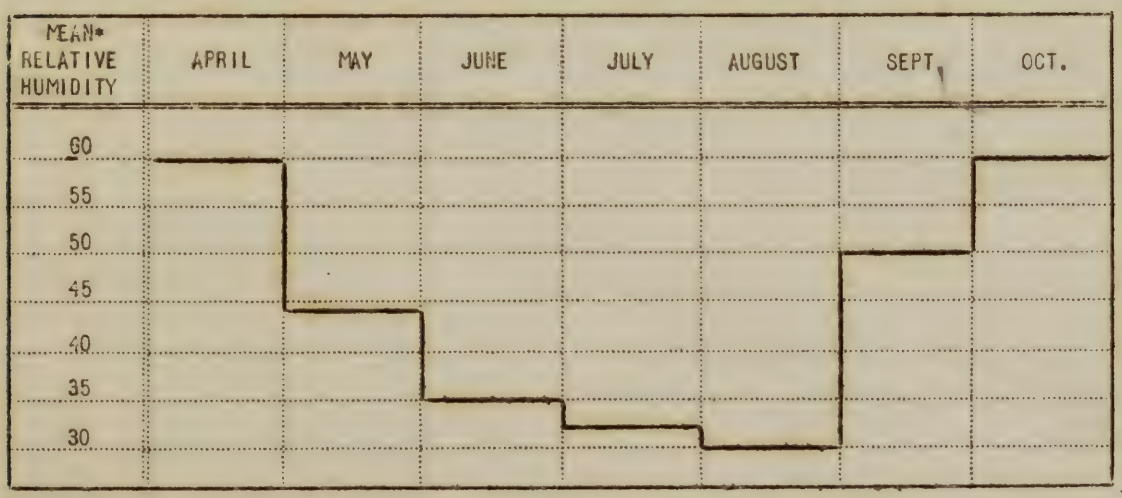
It is suggested that a pilot plant erected for the purposes above set forth include one or more of the commercial machines available for preparing vegetables for canning, a mechanical vegetable peeler, moisture testing equipment, equipment suitable for continuous recording of weather data and a drying rack affording wide range of adjustment. The following plans and specifications of a portable air dryer are offered as being practical for initial use. The probable capacity of the proposed rack, when set for average six-inch width is estimated, under stated weather conditions to be as follows:

ESTIMATED CAPACITY OF PROPOSED DRYER

432 CUBIC FEET RAW POTATOES

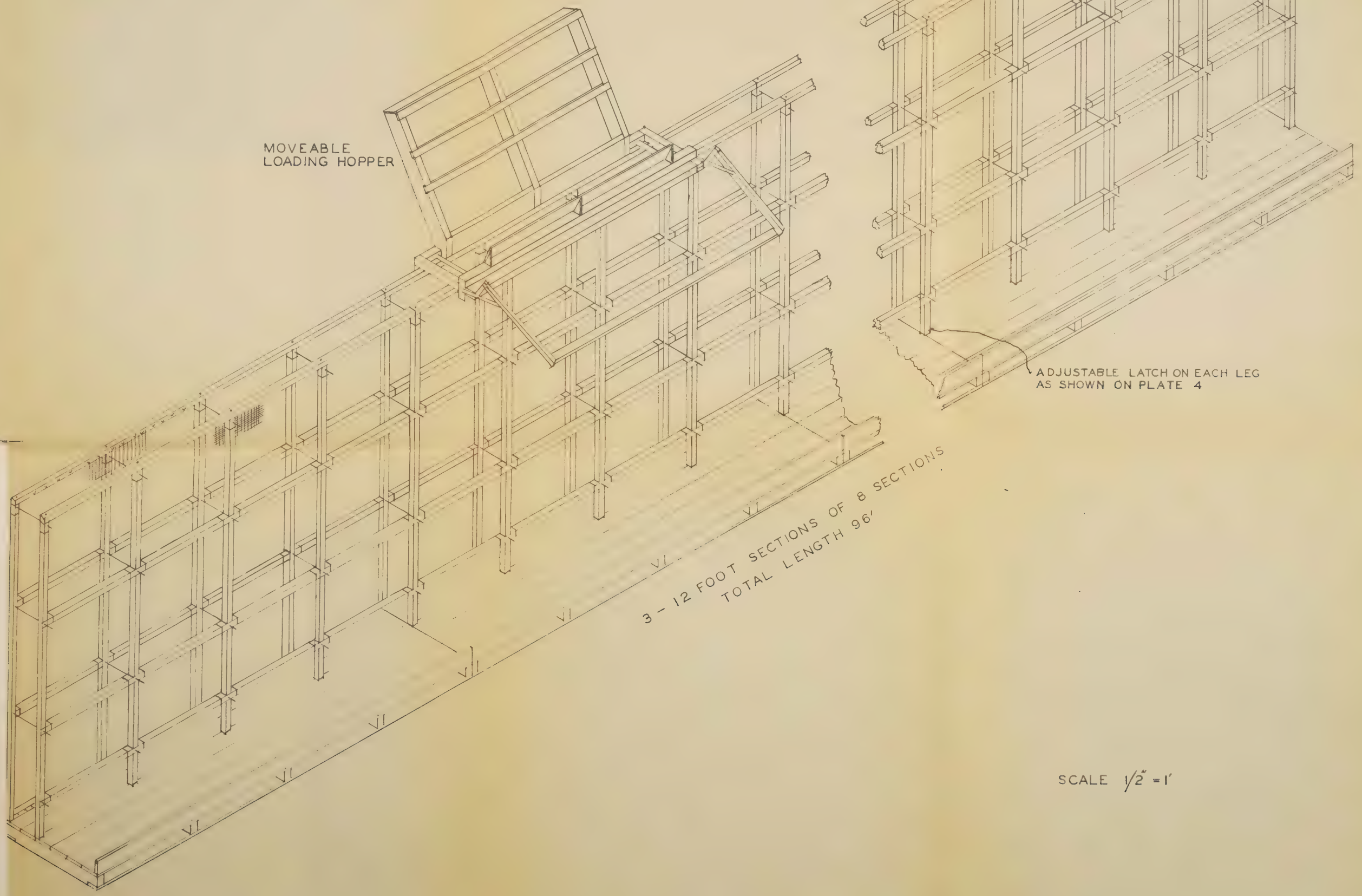






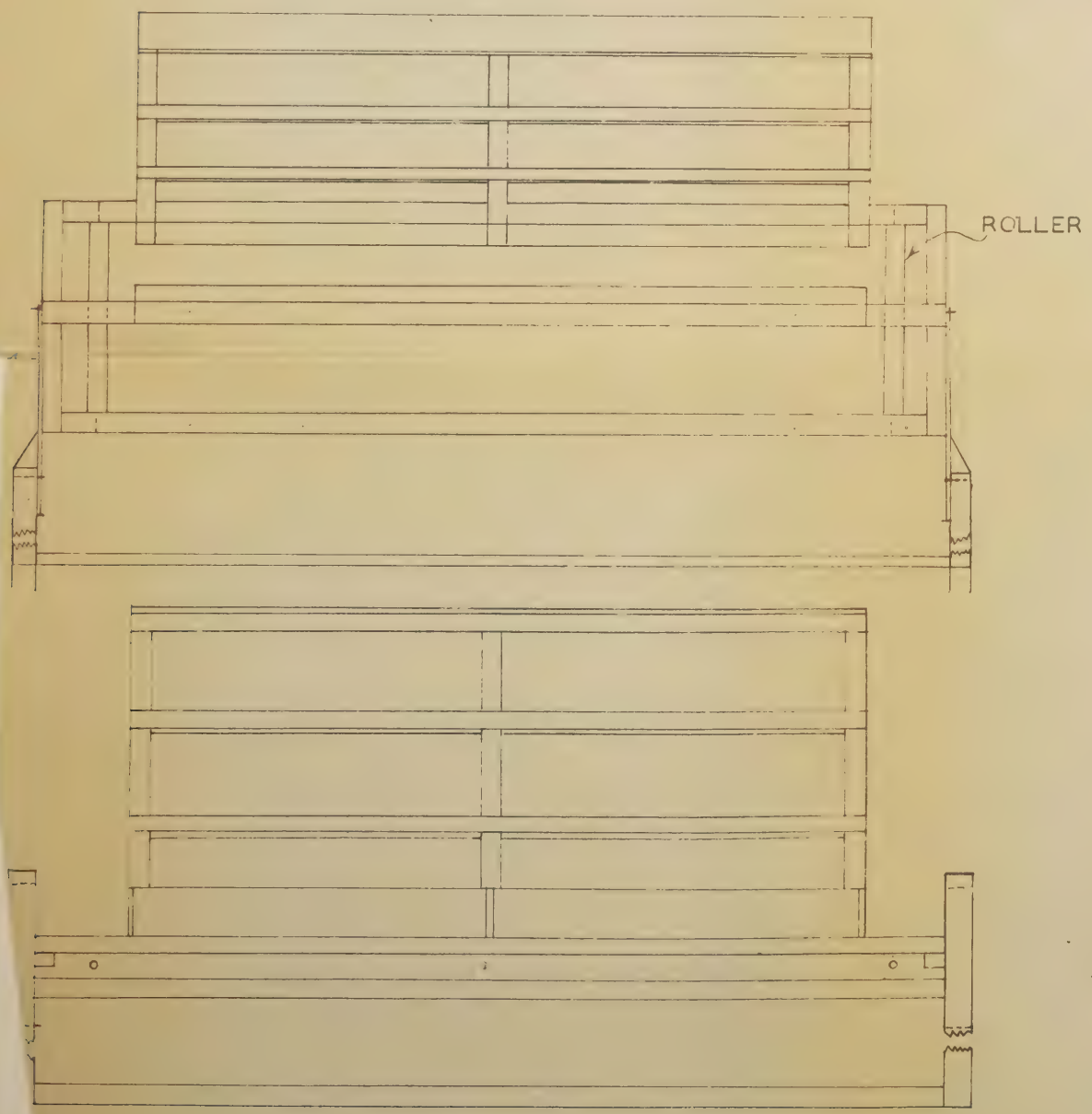
* BOISE WEATHER STATION DATA FOR 1940 .

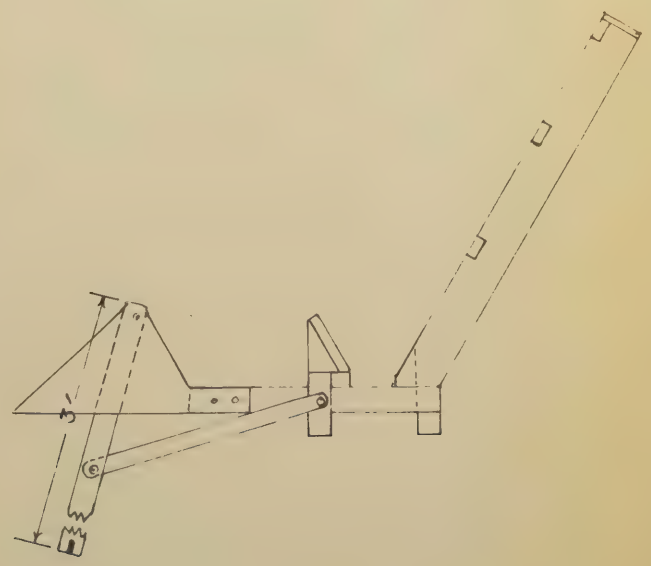
PLATE 1



SCALE 1/2" = 1'

PLATE 2

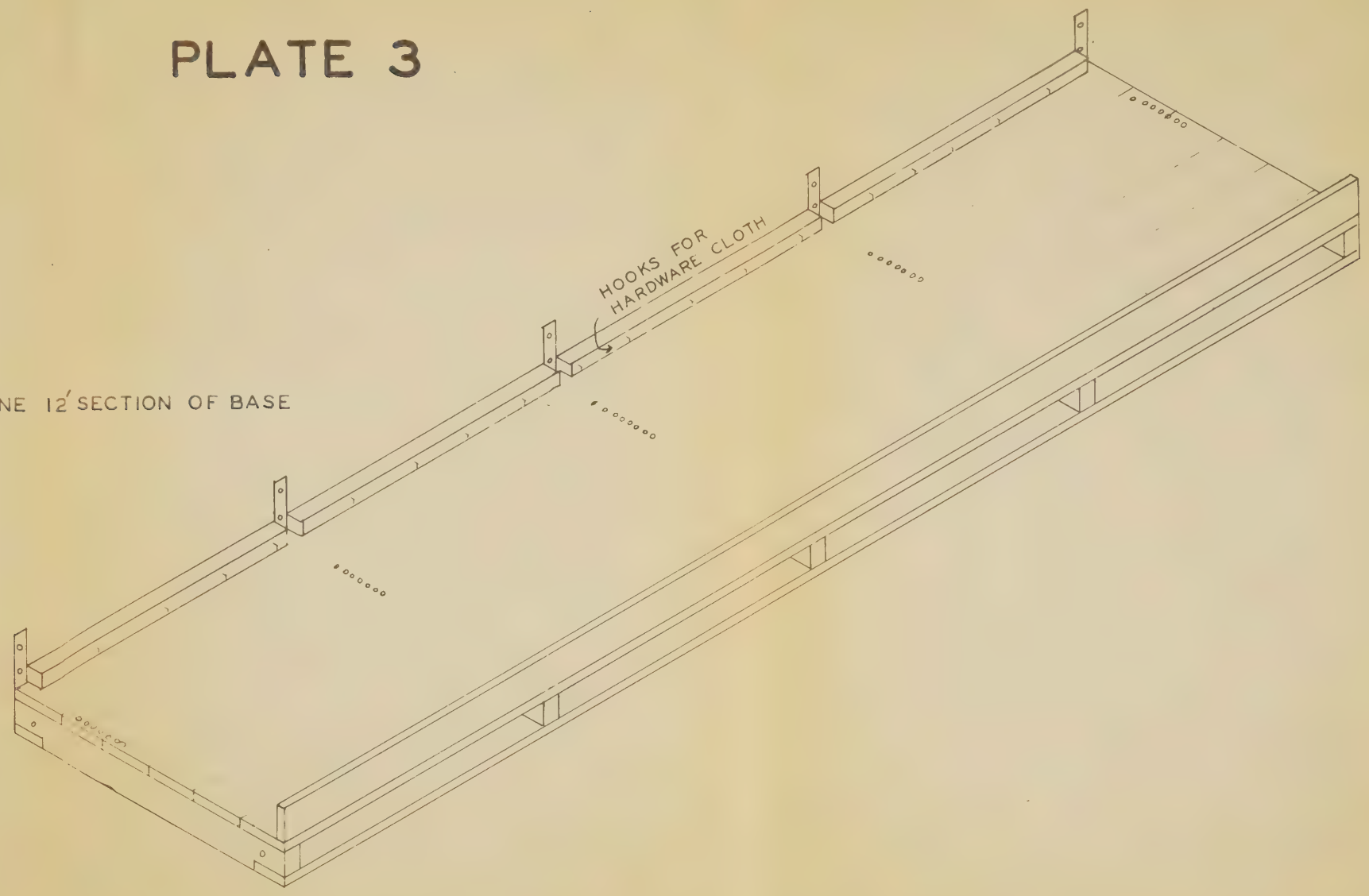


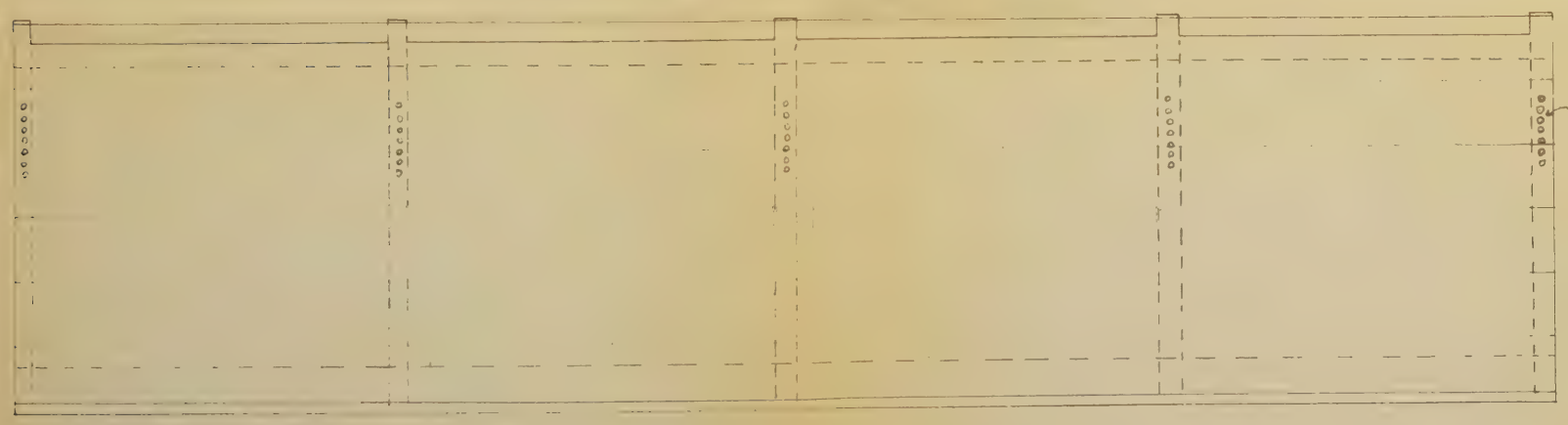


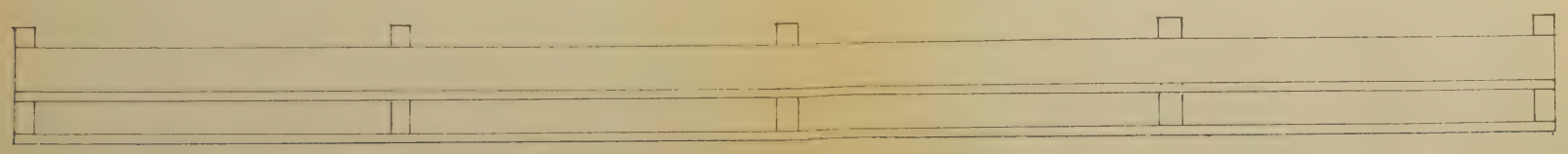
DETAIL OF LOADING HOPPER
SCALE 1 INCH = 1 FOOT

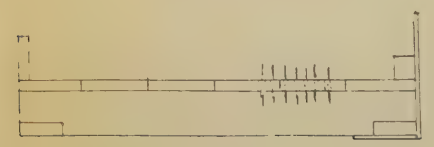
PLATE 3

DETAIL OF ONE 12′ SECTION OF BASE









SCALE 1"=1'

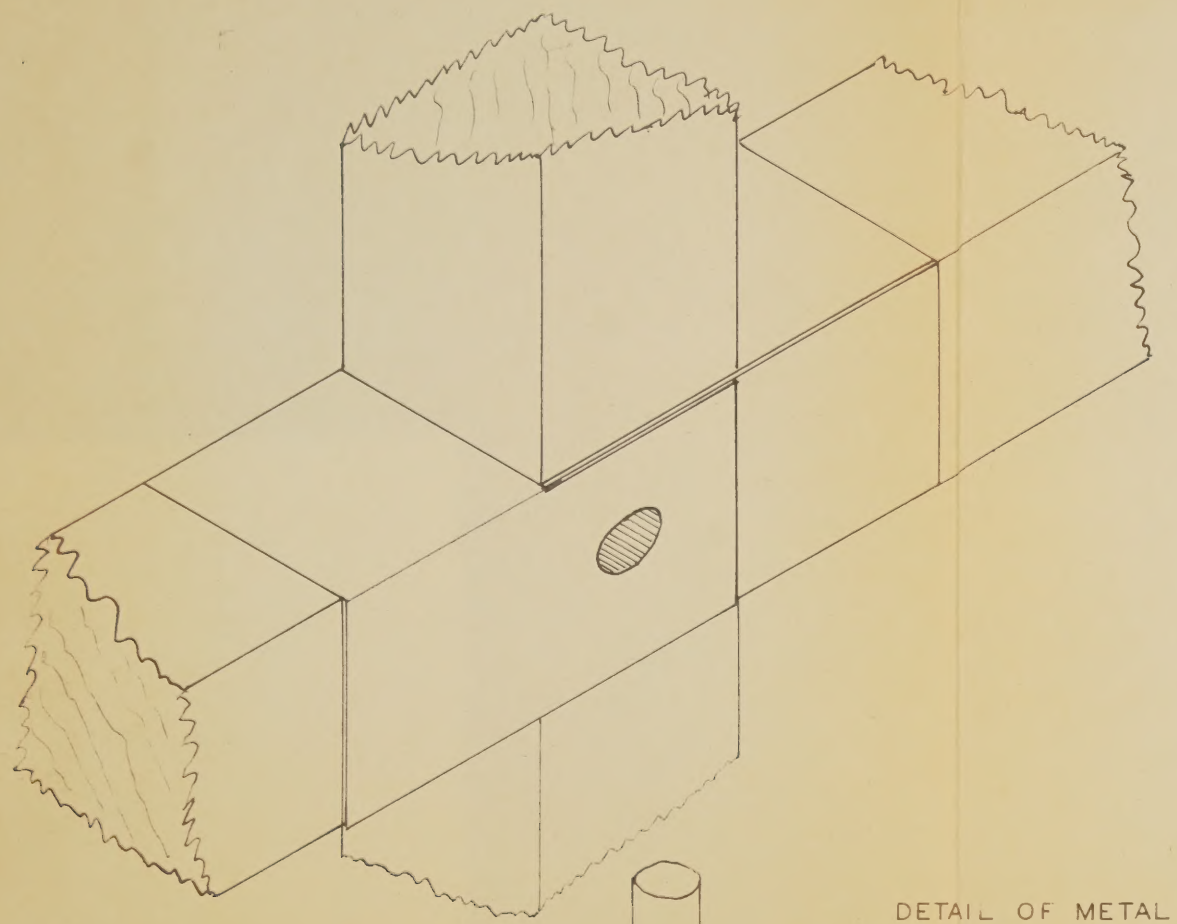
PLATE 4

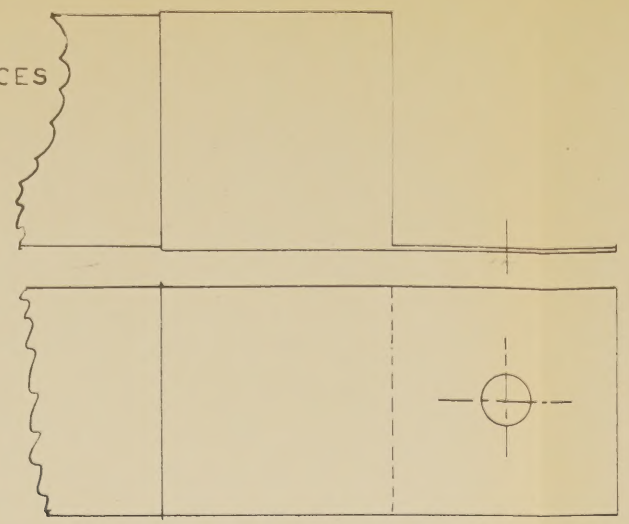
DETAIL OF CATCH FOR
BOTTOM OF VERTICALS
SCALE $\frac{1}{2}$" = 1"

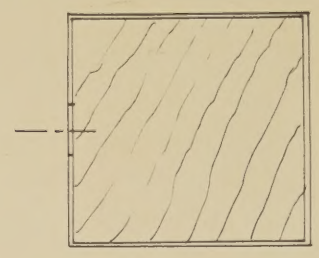
DETAIL OF END 12 FOOT SECTION
SCALE 1 INCH = 1 FOOT

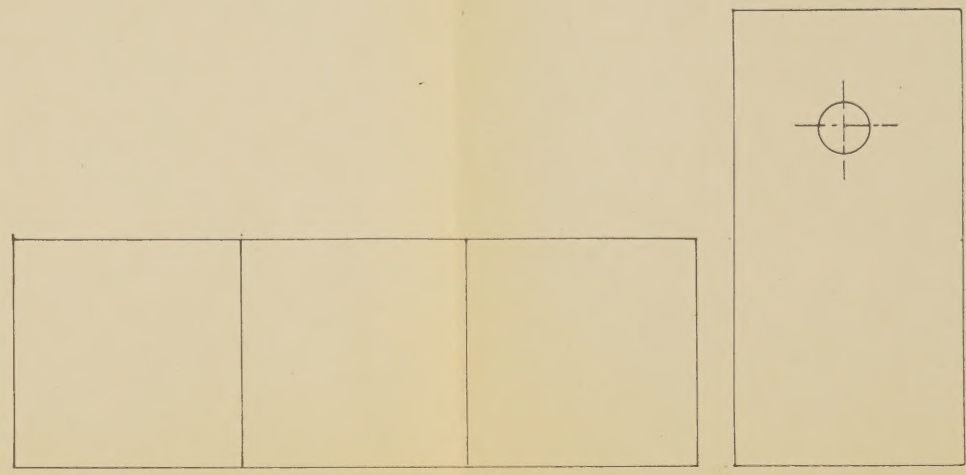
PLATE 5

DETAIL OF JOINT BETWEEN
VERTICAL & HORIZONTAL BRACES



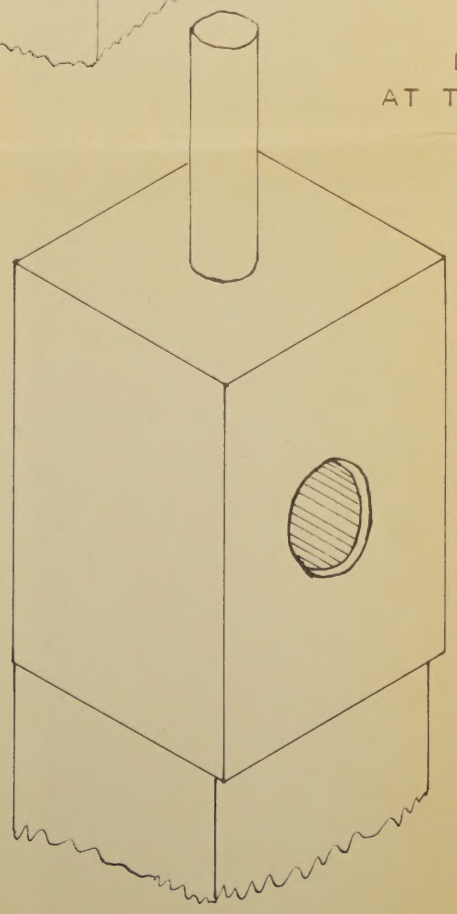


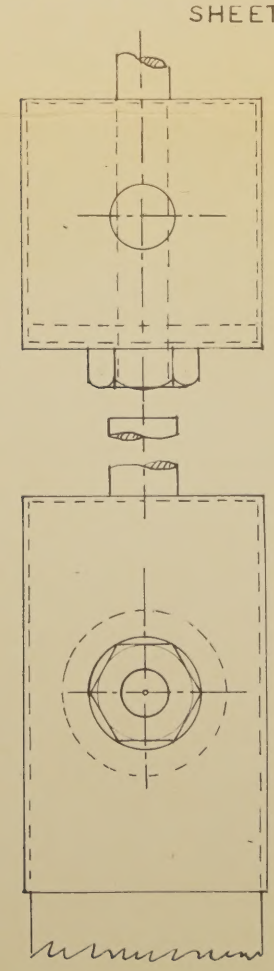


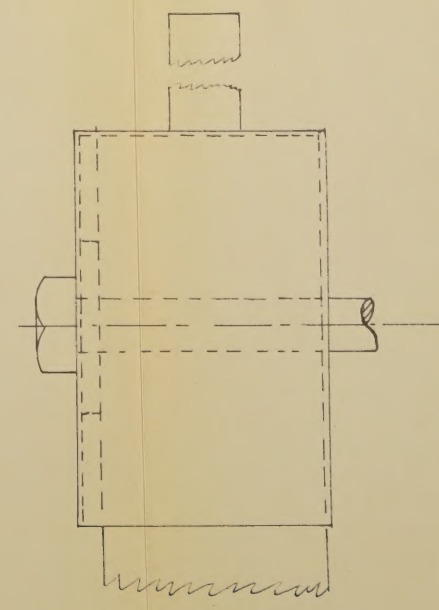


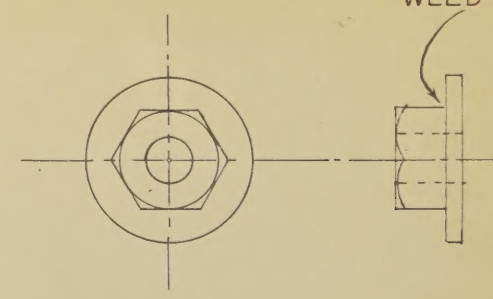
SHEET METAL LAYOUT

DETAIL OF METAL CAP
AT THE TOP OF VERTICALS









SCALE 1"= 1"